

Serious Incident

Aircraft Type and Registration:	Boeing 737-8200, EI-HET	
No & Type of Engines:	2 CFM LEAP-1B27 turbofan engines	
Year of Manufacture:	2019 (Serial no: 62310)	
Date & Time (UTC):	4 December 2023 at 1103 hrs	
Location:	London Stansted Airport	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 4	Passengers - 122
Injuries:	Crew - None	Passengers - None
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	46 years	
Commander's Flying Experience:	5,300 hours (of which 2,800 were on type) Last 90 days - 235 hours Last 28 days - 29 hours	
Information Source:	AAIB Field Investigation	

Synopsis

After an unstable ILS approach, a manually flown go-around (GA) was initiated at 1,940 ft amsl and 3.6 nm from touchdown. During the approach the mode control panel altitude display was set to 100 ft, but not reset to the missed approach altitude (MAA), prior to the GA being commenced. In the GA the aircraft committed a level bust as it climbed through the MAA of 3,000 ft amsl. Upon recognising this the PF pitched the aircraft down and entered a descent, having reached a maximum altitude 4,030 ft amsl. During the descent the aircraft reached a nose-down attitude of 17.7° and 295 KIAS, with Flaps 5 extended before a recovery and climb was initiated, during which its lowest recorded height was 1,740 ft agl. After the recovery was commenced the EGPWS warning sounded. The entire event occurred with the aircraft in IMC.

Prior to the GA the MAA was not checked by either pilot and during the GA the PF was fixated on the flight directors and expected them to command the aircraft to level off.

There have been several serious incidents which occurred during go-arounds with similar factors to that found in this investigation involving EI-HET. Although EI-HET is a Boeing 737-8200 [MAX], the incident could have occurred in any variant of the Boeing 737, or any other type of aircraft with similar autopilot and flight director systems.

As a result of this serious incident the operator has taken three safety actions including informing its pilots about this event and introducing a Discontinued Approach procedure.

History of the flight

The crew were operating a scheduled flight from London Stansted Airport to Klagenfurt Airport, Austria, and return, reporting for duty ahead of their rostered report time of 0555 hrs. The outbound flight was uneventful.

For the return flight to Stansted the commander was the PF and the co-pilot the PM. The departure and cruise proceeded without event. Prior to the descent the crew conducted an approach brief where they planned to conduct a radar vectored CAT I ILS approach to Runway 22 (Figure 3) for a Flaps 30 manual landing. They noted Stansted's ATIS information 'November' which stated the surface wind was from 130° at 12 kt. The visibility was in excess of 10 km, with overcast cloud at 400 ft aal and a QNH of 997 hPa. The initial part of the descent was uneventful. During the approach when the aircraft was below 6,000 ft, height changes were flown with a single autopilot (A/P) and the autothrottle (A/T) engaged, using Level Change mode (LVL CHG).

When the crew transferred to the Stansted Approach/Director¹ frequency, ATC cleared the aircraft initially to descend to FL80, followed shortly thereafter to 6,000 ft amsl and advised that they had 24 track nautical miles to touchdown². At this point the aircraft was passing FL86 (about 7,800 ft aal) and at about 235 KIAS. About one minute later ATC then cleared the aircraft to descend to 4,000 ft amsl, advising that it was now 20 nm³ from touchdown. At this point the aircraft was passing FL76 (about 6,800 ft aal) and still at 235 KIAS. About 90 seconds later, the ATCO noticed that the aircraft was a bit high for a continuous descent arrival⁴ (CDA), possibly due to a tailwind, so the aircraft was instructed by ATC to turn slightly away from the runway in order to give it some extra track mileage. At about 15.5 track nautical miles from touchdown, as the aircraft descended through about 6,000 ft amsl (5,650 ft aal) the speedbrakes were extended for about 35 seconds until the aircraft passed through about 5,200 ft amsl. The aircraft was then instructed by ATC to establish on the localiser (LOC) and was cleared to descend to 2,000 ft amsl, before being cleared to capture the ILS. At 12 nm, Flaps 1 was selected and the speedbrakes were extended again. The aircraft was then instructed by ATC to reduce speed to 180 KIAS. Flaps 5 was selected about 20 seconds later. Figure 1 shows EI-HET's radar flightpath as it approached Stansted, the GA, level bust and descent, and second approach and landing.

Footnote

- ¹ Stansted Approach and Director were combined on to one frequency due to low traffic levels.
- ² Stansted Airport MATS Part 2 stated '*The director is to calculate the optimum point at which to issue descent clearance from stack levels to enable the pilot to achieve an approximate 3° glide path. On receipt of descent clearance, the pilot will descend at the rate they judge will be best suited to the achievement of continuous descent without recourse to level flight.*'
- ³ Analysis after the event showed that the aircraft was 20.5 nm from touchdown at this point.
- ⁴ A CDA is an aircraft operating technique in which an arriving aircraft descends from an optimal position with minimum thrust and avoids level flight to the extent permitted by the safe operation of the aircraft and compliance with published procedures and ATC instructions.

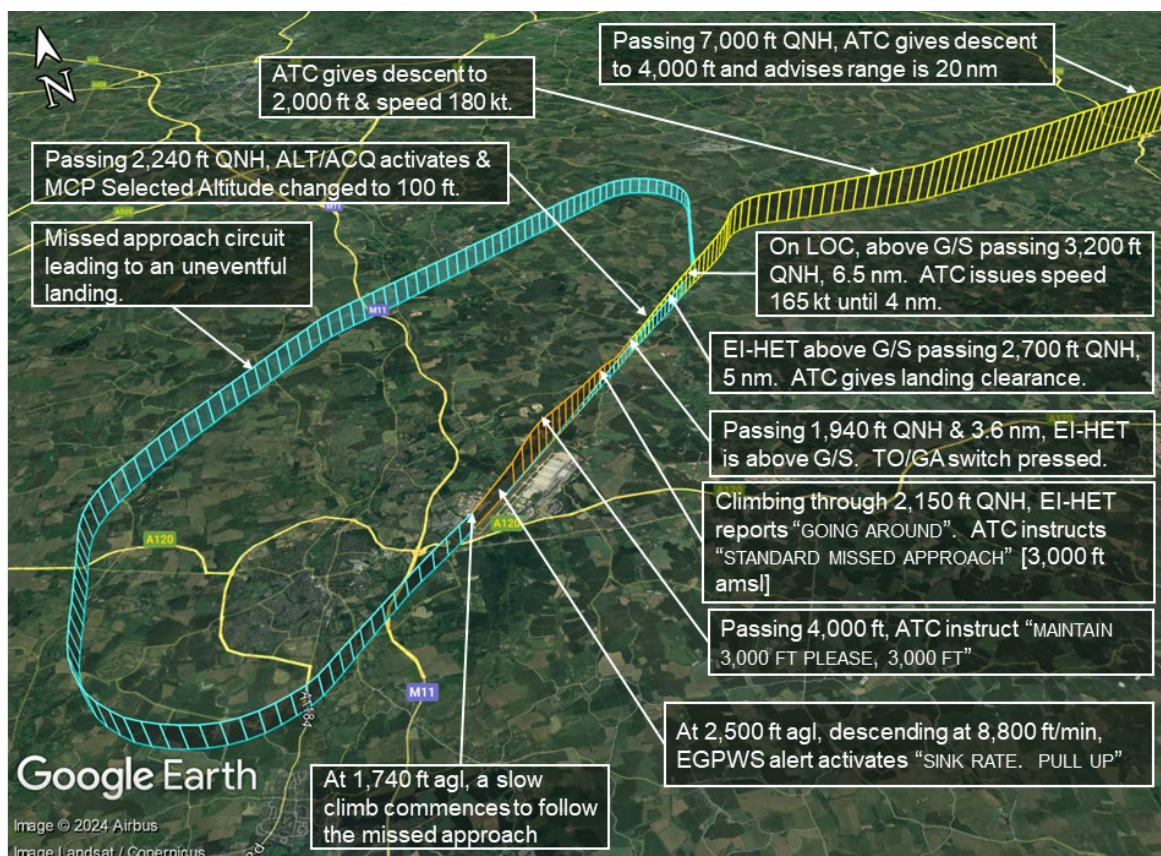


Figure 1

EI-HET's radar flightpath as it approached Stansted (yellow), the GA, level bust and descent (orange), and second approach and landing (blue)

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The LOC was captured at about 9 nm when the aircraft was 3,863 ft aal, with flaps 5, speedbrakes extended and at 195 KIAS. At this point the glideslope (G/S) was indicating full scale deflection below the aircraft. Flaps 10 was then selected. About 30 seconds later, when the aircraft was at 7 nm, ATC instructed the aircraft to reduce its speed to 165 KIAS until 4 nm and to contact Stansted Tower.

At 6 nm, as the aircraft passed 2,650 ft aal, the landing gear was lowered, the speedbrakes were extended and Flaps 15 selected. The speedbrakes were then retracted. At this point the airspeed was 186 KIAS. At about 5 nm ATC cleared the aircraft to land. The commander then commented that "IF WE DON'T CATCH IT [the G/S] WE'LL HAVE TO GO AROUND." As the aircraft was passing 2,240 ft amsl, at 171 KIAS, ALT/ACQ (altitude acquire) Flight Mode Annunciation (FMA) was displayed on the primary flight display (PFD) and Flaps 25 was selected. As a result, the commander set 100 ft in the mode control panel (MCP) altitude display, and selected LVL CHG. Shortly thereafter the commander said "LET'S GO AROUND".

At 1,940 ft amsl (1,579 ft aal) and 3.6 nm from touchdown, the commander initiated a go-around (GA) and the co-pilot advised ATC of this. See Figure 2 for EI-HET's approach from radar data, showing the path before the GA was initiated, and the aircraft's subsequent track.

ATC replied, “STANDARD MISSED APPROACH”. The commander took manual control, as the A/P automatically disengaged⁵, and followed the flight directors (F/D) that commanded 15° nose-up. The A/T advanced the thrust levers to a GA thrust⁶ of 82% N_1 on each engine. The co-pilot then selected Flaps 15 and the landing gear UP. Flaps 5⁷ was then selected as the aircraft passed 2,700 ft amsl.

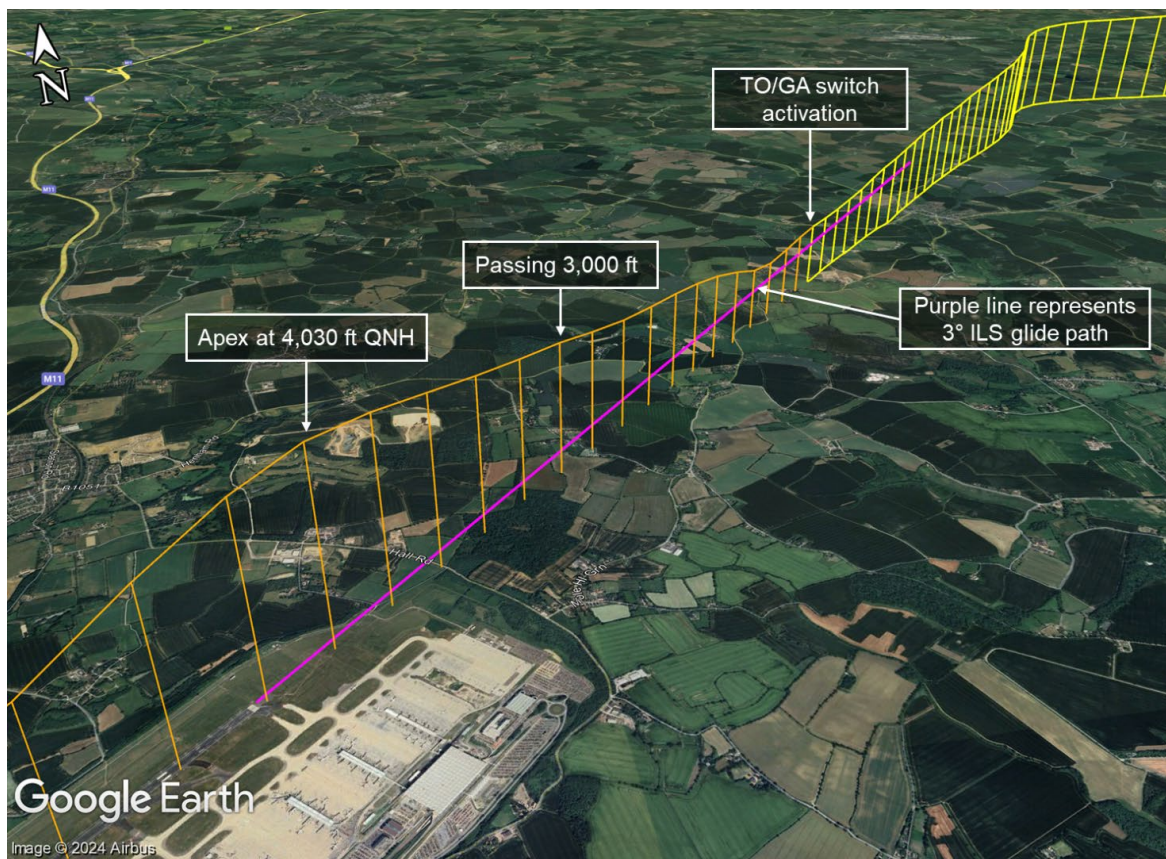


Figure 2

EI-HETs approach from radar data, showing path before TO/GA switch activation (yellow track), and subsequent track (orange track). 3° ILS G/S illustrated by purple line

Shortly after, the ATCO noticed on his aerodrome traffic monitor that the aircraft was at about 3,400 ft and climbing. During a GA at Stansted the aircraft has to remain below 3,000 ft amsl; as the aircraft had now exceeded that altitude (level bust) ATC instructed the aircraft to “MAINTAIN 3,000 FEET [AMSL] PLEASE, 3,000 FEET”, to which the copilot replied “MAINTAINING 3,000 FEET WILCO”. During this time, the speed remained relatively stable at about 180 KIAS.

Footnote

- ⁵ See *Aircraft Information* section below for more information on the A/P during a single channel approach and a GA.
- ⁶ See section on *Aircraft information* below for more details on the A/P.
- ⁷ The crew had planned to leave flaps 5 extended during the initial part of the missed approach procedure (MAP) until the right turn to BARKWAY was complete, as the MAP required a maximum of 185 KIAS, until the aircraft was established inbound on the 171° radial.

The commander then pitched the aircraft to about 5 to 10° nose-down, and made a nose-down trim input, to initiate a descent, during which 0.40 vertical g was recorded.

During the missed approach procedure (MAP) the aircraft reached a maximum pitch of 16° nose-up, a maximum climb rate of 4,100 fpm and an altitude of 4,030 ft amsl, before a descent was commenced, in manual flight, with the A/T engaged and GA thrust still set. The aircraft then started a descent during which the commander noticed the MCP altitude display was set at 100 ft, so reset it to 5,600 ft. As the IAS was now increasing, the co-pilot said to the commander, "WATCH YOURSELF...SPEED...SPEED", with the first call coming at about 235 KIAS. The commander then extended the speedbrakes and manually retarded the thrust levers to idle. However, as the A/T was still engaged they advanced back to GA thrust. The commander then manually retarded the thrust levers to idle again, but they advanced again so, on the co-pilot's suggestion, they were held at idle by the co-pilot. The commander then pitched the aircraft nose-up, during which a vertical acceleration of up to 1.89 g was recorded. Just after the recovery was initiated, the EGPWS "SINK RATE" and "PULL UP PULL UP" aural and visual warnings on the PFD were annunciated. The MCP altitude display was then set to the missed approach altitude (MAA) of 3,000 ft and the A/T was then disconnected. During the descent the pitch of the aircraft reached a maximum of 17.7° nose-down, a rate of descent of -8,880 fpm, and 295 KIAS with Flaps 5 extended⁸. The lowest altitude recorded was 2,078 ft amsl, 1,740 agl. The aircraft was subsequently recovered and stabilised in a shallow climb before it levelled at 3,000 ft amsl. The entire event occurred with the aircraft in IMC.

Once stabilised at 3,000 ft, the A/P was engaged and the flaps retracted. The A/T was then engaged. The aircraft was then radar vectored for an uneventful ILS and landing on Runway 22.

Pilots' comments

Commander

The commander commented that he did notice the aircraft was high on a 3° CDA, during the initial part of the descent prior to establishing on the LOC. He added that whilst this was not unusual, he believed we would be able to achieve the required approach path to continue with the ILS approach and landing. Also, he was not aware of any perceived time pressure from ATC that may have led to the aircraft becoming high on the 3° CDA.

The commander added that during the GA, as the aircraft was passing about 1,800 ft amsl, he believed he disconnected the A/T, but when the aircraft started to descend he realised this was not the case. As he had become fixated on the F/Ds during the GA, he did not notice the high rate of climb and believed 3,000 ft was set in the MCP altitude display. However, he did not have the capacity to check it and expected the F/Ds would command a level off at 3,000 ft. Whilst he recalled ATC's instruction to maintain 3,000 ft, it was then that he noticed the aircraft had already climbed through it. The commander accepted that he was startled during the descent.

Footnote

⁸ The Flaps 5 limit speed is 250 kt.

He added that he has previously flown “several” uneventful approaches where the G/S was captured from above in an aircraft and in the simulator. His training records indicated that he completed a minimum of 73 GA in various configurations and training and checking situations, over the past four years with the operator. Of these, four were completed in a ‘non-standard’ configuration. This included a specific ‘High Energy Approach Recovery’ exercise, detailing a GA from a similar situation, in 2021. Whilst he had flown several GA during his recurrent training in a simulator as PF and PM, this was the first one he had flown as PF in an aircraft. He had been PM during two other GA in an aircraft.

Co-pilot

The co-pilot commented that when the aircraft was descending through 5,000 ft amsl he thought the aircraft was “a bit high”, which was not unusual for Stansted, but they would be able to catch the profile further into the approach.

He did not recall he had practised a G/S from above during a recurrent simulator check but had manually flown GAs during most of his recurrent simulator checks⁹. His training records indicated that he had flown at least 46 GAs as either PF or PM in various configurations during training and checking situations, over about the past two years with the operator. Two were completed in a ‘non-standard’ configuration.

Airport information

London Stansted Airport is 348 ft amsl and has two runways orientated 04/22. The ILS approach chart for Runway 22 is at Figure 3. It stated that when an aircraft was on the 3° G/S it will descend at 320 ft/nm.

The MAP for Runway 22 was to climb straight ahead to not above 3,000 ft amsl, turning right at 3.1 DME, measured off the ILS, and then establish on the BARKWAY VOR 171 radial. The maximum speed for the turn is 185 KIAS until established on the radial.

Footnote

⁹ The operator subsequently confirmed that the co-pilot’s training records indicated that he had completed this training.

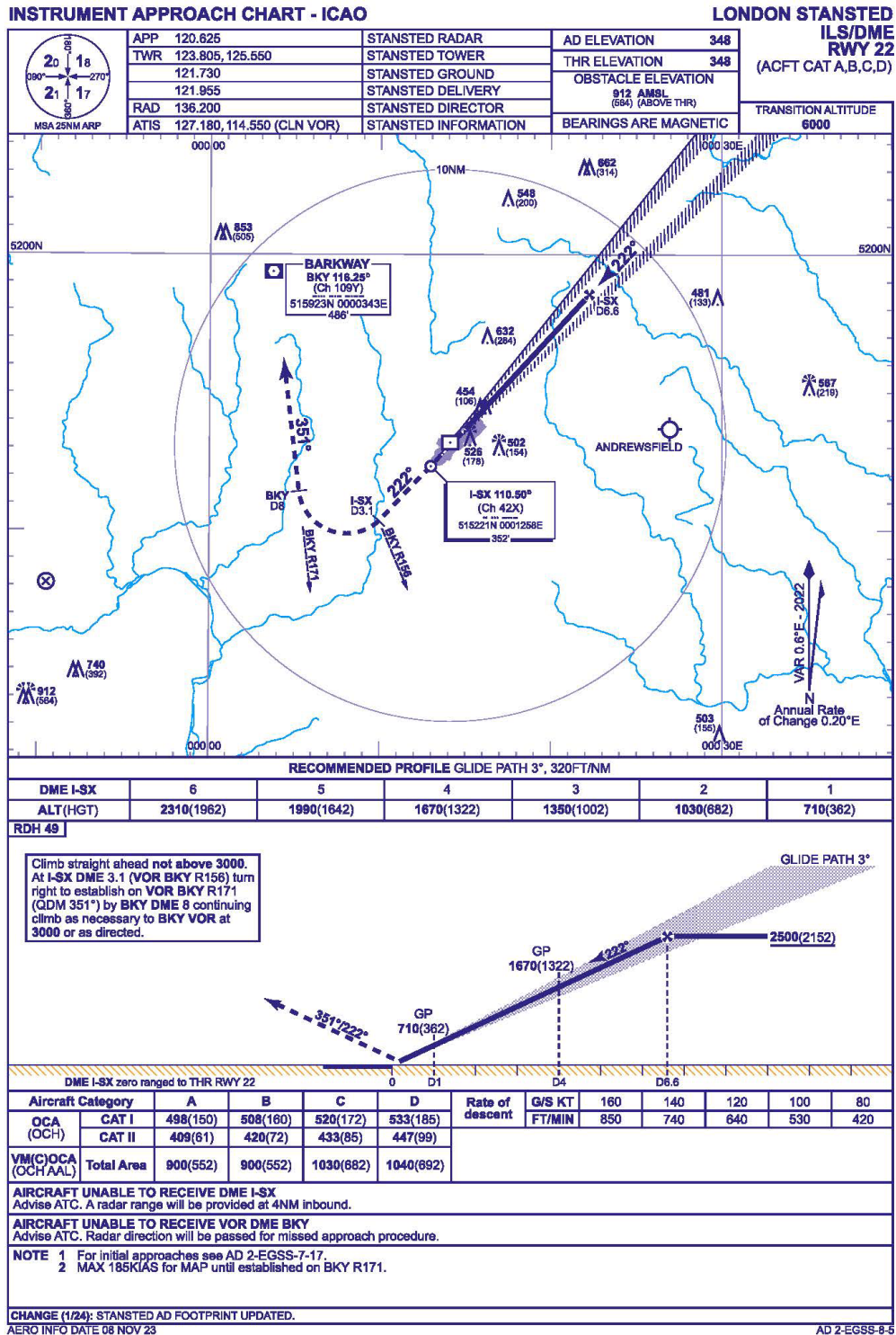


Figure 3

Approach chart for ILS to Runway 22 at London Stansted Airport (UK AIP)

There were three standard instrument departures (SID) from Runway 22 at Stansted that have a similar routing to the MAP; BARKWAY 5R, NUGBO 1R and UTAVA 1R. These route to the north inbound to the Barkway VOR and all have an initial climb clearance of 4,000 ft amsl.

Recorded information

Data sources

The Flight Data Recorder (FDR) and the Cockpit Voice Recorder (CVR) were isolated by the operator immediately following the incident. The EGPWS fitted to EI-HET was removed from the aircraft two days after the incident. All three items were recovered by the AAIB to its laboratory in Farnborough.

Recordings were obtained from Stansted Airport's Radar Surveillance System (RSS), which first detected EI-HET as it overflowed the English Channel. Mode-S transponder information, including the altitude selected on the autopilot MCP altitude display, was present in the recordings.

Recorded R/T transmissions captured ATC relaying track distances to the airport while providing radar vectors to the approach to EI-HET's flight crew. FDR position recordings were used by the AAIB to confirm that the track distance information provided by ATC radar during EI-HET's approach was accurate.

FDR

Figure 4 shows the pertinent FDR parameters for the event, with recorded RTF transmissions made by the flight crew to ATC. Activations of the EGPWS and Autopilot and Flight Director System (AFDS) modes are also shown. Each square along the x-axis represents 10 seconds.

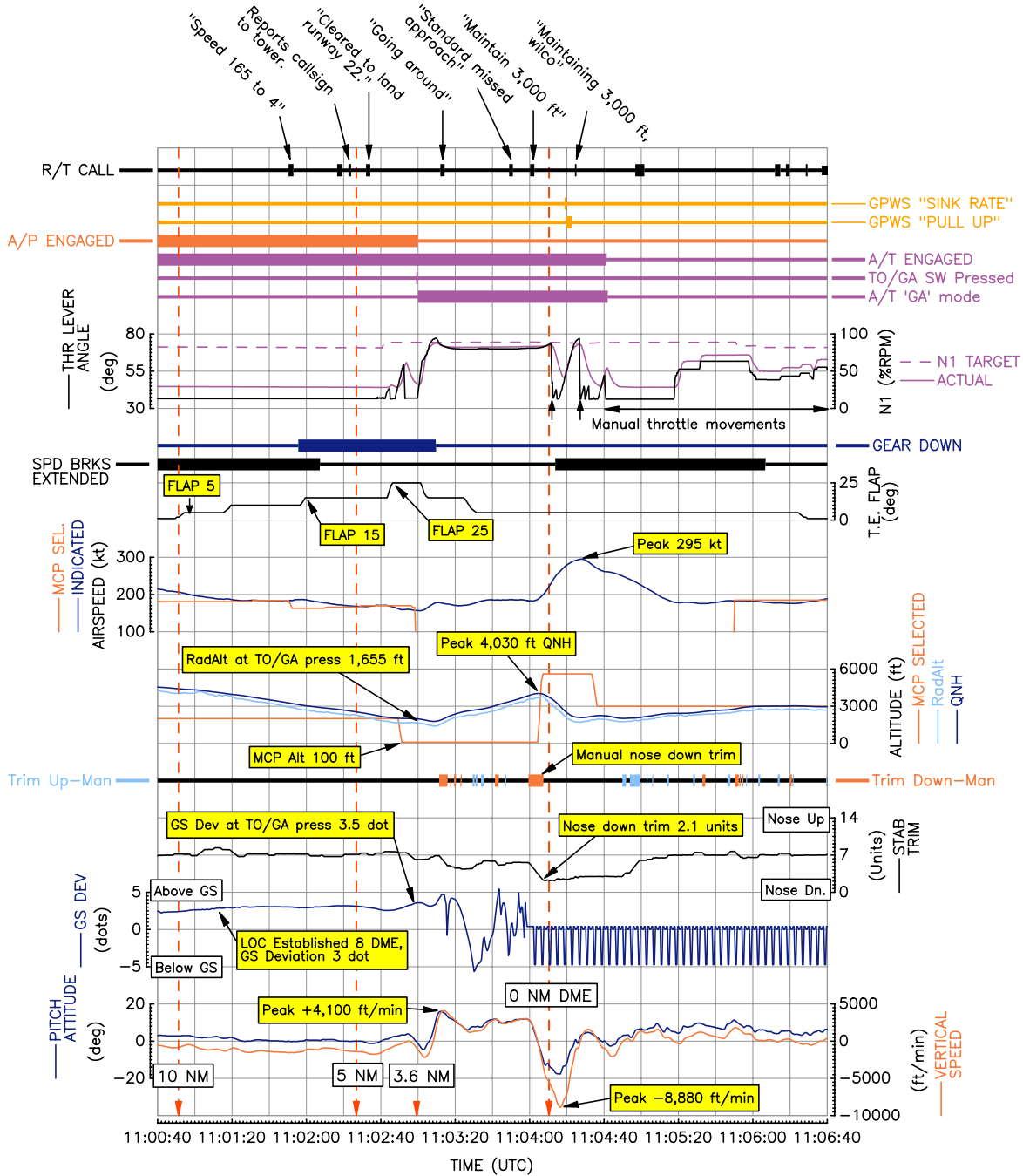


Figure 4
 Pertinent parameters from the FDR, with R/T transmissions to ATC

At the time of the descent during the MAP, the FDR recorded a forward control column input by the PF. The FDR also recorded pilot-commanded nose-down stabiliser trim movements, until the stabiliser reached about 2.5 units of trim, and the spoilers being extended.

Stabiliser trim movements

The FDR recorded Flight Control Computer (FCC) ‘up’ and ‘down’ stabiliser trim commands, and manual (pilot) trim-switch ‘up’ and ‘down’ commands, as discreet parameters. The data

indicated that the FCC commanded trim changes were normal. Manual trim inputs, and the position of the stabiliser trim (ranging from 0 units representing full nose-down trim, and 14 units representing full nose-up trim) are both shown in Figure 4.

The FDR indicated that the trim was manually commanded to a significant nose-down value of approximately 2.2 units, following ATC's prompt to maintain 3,000 ft following the level bust.

EGPWS Alerts

Logs were extracted from the EGPWS's memory and decoded with assistance from the manufacturer. The data indicated no faults, terrain inhibit events or inoperative statuses.

The data decoded for the incident flight was consistent with EGPWS activations recorded on the FDR, logging a single activation of the Mode 1 Inner Curve "PULL UP" warning, followed 0.03 seconds later by a single activation of the Mode 1 Outer Curve "SINK RATE" warning. Both activations occurred while EI-HET was above the runway flying on the runway heading, and after the commander had taken corrective action.

CVR

During the approach, there was no discussion to indicate that the flight crew were sharing their mental model as to where the aircraft was on a 3° CDA or considered the need to request additional track mileage to successfully intercept the ILS G/S. The first mention of how the approach was progressing, and that they might need to GA, was as the aircraft reached about 5 nm from touchdown, which is the point at which the operator's procedures required the approach to be discontinued if it was unstable, or not fully established on the ILS.

On the CVR, the EGPWS warning "SINK RATE. PULL UP, PULL UP" was heard during the recovery from the steep nose-down attitude.

Aircraft information

The operator's designation for this aircraft type is the Boeing 737-8200. It is a high-density seating version of the Boeing 737 MAX 8.

Autopilot and flight director

The automatic flight control system consists of the AFDS and the A/T. The AFDS and the A/T are controlled through the MCP and the flight management computer (FMC). The status of the AFDS and A/T are displayed to both pilots through Flight Mode Annunciators at the top of the PFDs. The F/D displays command bars on the primary flight display when a pitch and/or roll mode is selected on the AFDS.

The LVL CHG mode coordinates pitch and thrust commands to make automatic climbs and descents to pre-selected altitudes at selected airspeeds; these are displayed by the F/D. The A/T engages automatically when LVL CHG is engaged.

In manual flight, all MCP mode selections will be called for by the PF and made by the PM.

The operator's Flight Crew Operations Manual (FCOM), stated that the A/P can be reengaged during a GA once the aircraft has levelled off at the MAA after the flaps have been retracted. The MAA is to be set in the MCP altitude display once the G/S is captured.

Go-around mode

The Boeing 737-8200 is a dual A/P, CAT III approach and landing capable aircraft. Normal manual landing procedures require the use of a single A/P on an ILS approach unless the intention is to conduct an automatic CAT II or III approach and landing. Automatic GA are only available from a dual A/P approach. The AFDS GA mode is engaged by pressing one of the TO/GA switches located on the thrust levers. Pressing either of the switches when the engagement criteria are met will disconnect the single A/P (if connected) and place the F/D in GA mode. The A/T (if engaged) will move to GA thrust, and the F/D will then command 15° nose-up pitch. The handling pilot would then follow the F/D commands and level the aircraft at the altitude selected in the MCP altitude display. Below 2,000 ft radio altitude, one press of a TO/GA switch will cause the A/T (if engaged) to advance to a power setting for a climb rate between 1,000 and 2,000 ft/min. With two presses of a switch, the A/T (if engaged) will advance to the full GA N₁ limit. Above 2,000 ft radio altitude, one press of a TO/GA switch commands thrust to the full GA N₁ limit. The GA was initiated below 2,000 ft.

Autopilot altitude modes

The AFDS can capture and hold an altitude pre-selected in the MCP display window. These modes are ALT ACQ and altitude hold (ALT HOLD). When the AFDS is engaged in TO/GA mode, the pitch mode will change to ALT ACQ when approaching the altitude selected on the MCP. ALT HOLD commands pitch to hold the selected altitude.

Flaps

The aircraft has eight stages of flaps; 1, 2, 5, 10, 15, 25, 30, 40. The speed limits for each stage of flaps are in Table 1:

Flaps	Limit (kt)	Flaps	Limit (kt)
1	250	15	200
2	250	25	190
5	250	30	175
10	210	40	166

Table 1
Boeing 737-8200 Flaps Limits

Organisational information

The operator flies both the Boeing 737-NG [Next Generation] and Boeing 737-8200 [MAX] variants with its pilots being qualified to fly both. The following procedures are the same for both types.

Operations Manual (OM) Part A

The operator's OM states that for approaches flown in IMC, the aircraft should be stabilised for landing before reaching 1,000 ft above the landing runway threshold elevation.

Boeing 737-8200 FCOM

The operator's FCOM stated in '*Landing Procedure – ILS...*', that after the G/S is captured, the MAA is checked in the FMC and then set by the PF, after which the PM cross-checks it. It also stated that when the aircraft is being flown manually, all MCP mode selections will be called for by the PF and made by the PM.

It also states that "SPEED" is to be called whenever the IAS is greater than $V_{FLY} + 10$ kts or when the speed trend shows a significant tendency to exceed either of these parameters and thrust lever position is inappropriate for the phase of flight. V_{FLY} is the airspeed that is either selected by the crew, requested by air traffic or commanded by the FMC.

The operator's FCOM also stated the following:

'Approach Procedure

The configuration of Flaps 5, Speedbrake at Flight Detent and a speed of 220 knots is an effective initial speed/configuration mix. To assist further deceleration use 180 knots, flaps 10, and Speedbrake to Flight Detent, if necessary. This will give the best rate of descent per nautical mile.

Intercepting the Glide Slope From Above

Technique:

The following technique will assist the crew intercept the G/S safely and establish stabilized approach criteria by 1,000 ft AFE [above field elevation]. in IMC and 500 ft AFE in VMC:

- 1. Establish on LOC.*
- 2. Set the MCP altitude no lower than 1,000 ft AFE. [1,400 ft for Stansted].*
- 3. When cleared for approach, take time to validate G/S (distance/height cross check).*
- 4. Arm APP Mode when within 1 dot above G/S.*
- 5. Configure the aircraft to establish at least Flap 5 configuration, Flap 5 speed (maximum Flap 5 speed + 10 kts) by 2,000 ft AFE or the altitude specified on the approach chart if higher when conducting a procedural ILS approach.*

6. *Achieve G/S or Path capture by 5 nm...from the RW [runway] point for all ILS/GLS approaches and be fully stabilized by 1,000 feet AFE in IMC...*

Note: It is policy to establish on the glideslope by 5 nm...from the RW point for all ILS/GLS Approaches.

This procedure provides a 'stabilized' glideslope capture target of 5 nm...from the RW point for all ILS/GLS approaches, at or below 180 kts, while the 1000 ft AFE in IMC and 500 ft AFE in VMC landing gate limits remain in place.'

There was no mention of resetting the MCP altitude display to the MAA in the above 'technique'. However, the operator commented that as the *Landing Procedure* should still be completed after the G/S has been captured, the MAA should be set and checked.

As a result of this serious incident the operator has introduced a *Discontinued Approach* procedure in its FCOM. This new procedure was reviewed by the manufacturer and approved by the operator's National Aviation Authority. See Appendix A.

Fatigue

The commander and co-pilot were both on their fourth day of five days consecutive work, all with report times before 0700 hrs. Prior to this they were on leave for three weeks, which the co-pilot spent in a time zone five and a half hours ahead of the local time in Stansted.

On the day of the incident the crew reported for duty before 0555 hrs. This was the first time they flew together during this block of work.

The co-pilot stated that although he felt he had adequately rested and was fit to fly, he did feel tired. He added that he probably felt like this as his period of leave was spent in a hotter climate and a few days after this incident he became unwell with a cold.

The investigation collected and analysed sleep and work history and physiological information for both flight crew. This information did not indicate the presence of any fatigue risk factors on the day of the incident, or in the days prior.

Somatogravic illusion assessment

Somatogravic illusion¹⁰ is one of the most common forms of vestibular or 'false sensation' illusions which is typically experienced during linear acceleration or deceleration when climbing or descending. In an acceleration case, this can cause a pilot to perceive that the aircraft is pitching up more than it actually is, leading them to push on the control column to overcome their perception.

Footnote

¹⁰ More information on somatogravic illusions can be found here: <https://skybrary.aero/articles/somatogravic-and-somatogyral-illusions> [accessed September 2024].

The aircraft manufacturer reviewed the flight data using its 'Spatial Disorientation Investigation Tool' (SDiT) to see what the potential was of the GA to induce spatial disorientation to the pilots. The results of this indicated that the perceived pitch angles and pitch rates may have been different from the recorded values, indicating the potential for spatial disorientation during this GA. It is important to note that these results are not a guarantee that disorientation did take place, only that the recorded conditions indicated it was a possibility.

Other events

The AAIB has investigated other GA incidents which have similarities to EI-HET¹¹, and the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) published a report into a similar incident at Paris Orly Airport¹².

The operator had a GA incident at Eindhoven Airport, the Netherlands, in May 2013 that was investigated by the Dutch Safety Board¹³. As a result of this event the operator issued guidance in its FCOM on capturing a G/S from above.

Aircraft inspection

Following this event, the operator's engineers completed overspeed checks including on the aircraft's flaps and slats. No damage was discovered, and the aircraft was returned to service two days later.

Analysis

Initial approach

EI-HET was conducting a radar vectored CAT I ILS approach in IMC to Runway 22 at Stansted Airport, where its crew were based. As the aircraft was in IMC throughout this serious incident, there were no external visual cues with which to assist the crew in maintaining spatial orientation. They were thus reliant on the aircraft's flight instruments. The volume of air traffic in the area at the time was described as low, and there was no perceived pressure on the flight crew or the ATCO's. Between approximately 20 and 15.5 nm from touchdown the aircraft was close to being on a 3° CDA. During this period, believing that the aircraft was a little high for a CDA, the ATCO gave the aircraft a heading adjustment to give it more track mileage to lose some height.

Footnote

¹¹ Report into the serious incidents involving G-FDZF, <https://www.gov.uk/aaib-reports/aaib-investigation-to-boeing-737-8k5-g-fdzf> [accessed September 2024], G-THOF, <https://www.gov.uk/aaib-reports/aar-3-2009-boeing-737-3q8-g-thof-23-september-2007> [accessed September 2024], and I-NEOT, <https://www.gov.uk/aaib-reports/aaib-investigation-to-boeing-737-86n-i-neot> [accessed September 2024].

¹² <https://bea.aero/en/investigation-reports/notified-events/detail/serious-incident-to-the-boeing-737-registered-7t-vjm-operated-by-air-algerie-on-06-12-2019-at-paris-orly/> [accessed September 2024].

¹³ <https://onderzoeksraad.nl/en/onderzoek/stick-shaker-warning-on-ils-final-eindhoven-airport/> [accessed September 2024].

By the time the aircraft was established on the LOC at 9 nm, the aircraft was at 3,863 ft aal, about 1,000 ft above the G/S, with Flaps 10 selected and with the G/S indicator showing 3-dots below. Had more stages of flaps been deployed, and possibly the landing gear lowered, prior to the LOC being captured this would have increased the aircraft's drag, and rate of descent, assisting it to capture the G/S.

At about 4 nm, and having recognised that they would be attempting to capture the G/S from above, the MCP altitude was incorrectly reset from their last descent clearance to 100 ft, about 10 seconds before the GA was initiated. It should have been set to 1,400 ft (1,000 ft AFE). Had it been reset earlier in the approach it would have offered the crew more time to notice the incorrectly set MCP altitude. This too would have avoided the aircraft entering ALT ACQ as it approached the last ATC cleared altitude of 2,000 ft amsl. This caused a distraction and a peak in the commander's workload as he had to reset the MCP to a lower altitude and select LVL CHG to keep the aircraft descending. Given these multiple MCP selections it is possible that the commander set the MCP altitude in haste without checking it. Whilst the crew may have believed they could have captured the G/S within the limits specified in the operator's OM, this was not achieved, and they correctly decided to conduct a GA. As the MCP altitude was still set to 100 ft, and not the MAA, the F/Ds would not have commanded a level off. Whilst the operator's *Landing Procedure - ILS* stated that the MAA should be set and checked at G/S interception, there was nothing explicit in the G/S from above technique to give the crew guidance on when to set the MAA. However, the operator commented that it was implicit given it is to be checked as part of the Landing Procedure.

At no point during the approach did either crew member share their mental model as to where they thought the aircraft was on the 3° CDA profile until the likelihood of a GA was mentioned by the commander at about 5 nm. It is essential that flight crew share their mental model throughout all phases of flight so that if there is a discrepancy this can be discussed in good time so prompt action can be taken to resolve the issue, before more positive action, like a GA, is required.

Missed Approach Procedure (MAP)

The initial part of the GA was correctly flown, despite the commander stating he was fixated on the F/Ds. This fixation was probably a result of the high workload experienced during the instrument approach, which subsequently increased, along with some startle factor, when the GA was initiated. Had the MAA been set correctly it is likely the commander would have followed the F/Ds and levelled the aircraft at the required altitude of 3,000 ft. However, with an MCP altitude below that of the aircraft, the F/D continued to command a climb until either an altitude above the aircraft was set or there was some manual flying intervention by the PF, with the latter being the case in this event. Once the crew recognised they had flown through the MAA they established a descent to correct the situation.

The GA was initiated at 3.6 nm and 1,940 ft amsl. Once the aircraft was in the climb, with GA power applied, there was little time to recognise the lack of guidance from the flight director to capture the altitude and level off at 3,000 ft without guidance from the F/Ds. However, as there was no urgency to commence the GA at this point, had the crew continued with the approach for about another 2 nm, it would have given them about 40 seconds to conduct a 'mini-brief' in which they could remind themselves of their actions in the GA and given them the opportunity to check the MAA was set correctly.

Whilst the commander recognised he needed to lower the nose to descend, which he initially set between 5 and 10° nose-down, the subsequent nose-down attitude was probably a result of the push on the control column, a nose-down trim input and a pitch/power couple when the thrust levers were closed from a high-power setting to idle. At this time the MCP altitude was reset by the commander, initially to 5,600 ft, probably in haste, before being correctly set to the MAA of 3,000 ft. Had he requested the co-pilot to do this, as stated in the FCOM, he would have had more of his limited capacity available for his primary task of flying the aircraft.

During the descent the aircraft reached a maximum pitch of 17.7° nose-down, a descent rate of 8,880 fpm, and an airspeed of 295 KIAS with Flaps 5 extended; the lowest recorded height was 1,740 ft agl. The commander recognised the excessive nose-down attitude and initiated a recovery just before the EGPWS was triggered. Had he not initiated the recovery before the warning occurred, the EGPWS's aural and visual warnings were a safety barrier that would have alerted the crew to the high rate of descent close to the ground, and this should have caused them to take appropriate recovery actions.

The co-pilot's first call of "SPEED" was during the descent from 4,000 ft, when the aircraft was at about 235 KIAS and accelerating. This was about 40 kt greater than the OM requirement to call "SPEED" at 195 KIAS ($V_{FLY} + 10$). This delay in calling "SPEED" could be explained by the co-pilot experiencing some form of startle and surprise by the dynamic nature of the manoeuvre. His attention may also have been focused elsewhere in the cockpit before he recognised the situation.

The GA was initiated at 3.6 nm. Given there was no urgency to initiate it, the crew could have elected to continue with the approach until about 1 nm from touchdown, assuming the MCP altitude had been reset to the MAA. Given the aircraft was flying at about 180 kt, it gave the crew about 40 seconds in which to compose themselves and brief what actions they were each going to perform during the GA, including a check that the MAA was set correctly. Had it been set when the GA was initiated this serious incident probably would not have occurred.

There are three SIDs, from Runway 22, that route to the north of the airport, all with an initial climb clearance of 4,000 ft amsl. Had an aircraft departed close to the time EI-HET initiated the GA there was a possibility that the two aircraft may have come into conflict with each other.

Somatogravic illusion

The manufacturer's study of this event suggested that there was potential for spatial disorientation during this GA. However, given that the commander was predominately fixated on the F/D during the GA and there was no significant pitch down input until after the level bust, it is more likely that the push on the control column was a response to the PF realising they had flown through their cleared altitude of 3,000 ft amsl, rather than any perceived visual illusion. Hence it is unlikely that the commander experienced spatial disorientation.

Conclusion

This serious incident occurred because the Missed Approach Altitude (MAA) was not set in the Mode Control Panel (MCP) before a go-around was performed. It was not set to the MAA because the flight crew were attempting to intercept the glideslope from above. This required the MCP selected altitude to be set to a height below the aircraft, and the MCP selected altitude was not adjusted to the MAA following the decision to go-around before it was executed.

The approach and go-around were flown in instrument meteorological conditions (IMC) and hence the pilots had no external visual references. During the go-around the pilot flying was fixated on the Flight Directors and did not recognise that they did not command a level off at the MAA until it had flown through it.

The subsequent recovery manoeuvre from the level bust was probably exacerbated by the thrust levers being moved from a high-power setting to idle resulting in an excessive nose-down attitude, rate of descent and IAS for the aircraft's configuration. Given the aircraft's height during this descent the Enhanced Ground Proximity Warning System was triggered just after the commander had initiated a pitch up into a climb back to the MAA.

This serious incident involved a Boeing 737-8200 [MAX]. It could have occurred in any variant of the Boeing 737, or any other type of aircraft with similar autopilot and flight director systems. There have been other serious incidents, with similarities to the EI-HET that have been investigated.

Safety actions

As a result of this serious incident the operator has taken the following safety actions:

Re-emphasised to all pilots the correct go-around procedure via a mandatory learning module.

Introduced a training package covering high energy approaches and all engines go arounds, demonstrating non-standard or unexpected go-around conditions, in their 'summer 2024' recurrent training package.

Introduced a 'Discontinued Approach Procedure' in June 2024 that can be used when an approach is ceased prior to glideslope capture or if the approach gate requirements in its operations manual cannot be achieved. This was backed up with a *Chief Pilot Alert* to all pilots, via their portable electronic devices, highlighting this serious incident and the new procedure. This procedure is included in Appendix A below.

Appendix A

Discontinued Approach

As a result of this serious incident the operator introduced the following procedure in the *Normal Procedures* of its FCOM.

'Discontinued Approach'

The Discontinued Approach procedure shall be utilised to confirm AFDS selections and aircraft configuration prior to commencing a Go Around above the 500' stabilized approach call when:

- • *Not in the landing configuration and,*
- • *Above minimums.'*

Pilot Flying	Pilot Monitoring
Call "Discontinued Approach".	
Retract speedbrakes.	
The PF shall point to the Missed Approach Altitude on the FMC LEGS page and call "XXXX FEET". The PF shall then set the Missed Approach Altitude in the MCP Altitude, point to it and call "SET".	
	Verify correct MAA displayed on the PFD and call "XXXX CHECKED".
Confirm landing gear configuration.	
Confirm flap configuration.	
Call "Ready?".	
	Verify all needed actions have been completed and callout any omissions. Call "Ready" once confirmed.
If below the MAA: <ul style="list-style-type: none"> • Push TO/GA, • Call "GO-AROUND FLAPS __." • Conduct the go-around procedure appropriate to the current configuration*. If at or above the MAA: <ul style="list-style-type: none"> • Confirm AFDS status. • If required, de-tune ILS frequencies. • Select / verify appropriate roll mode. • Select / verify appropriate pitch mode. • Level off at the MAA. • At ALT HOLD, bug up, retract flaps & gear on schedule. • Perform the AFTER TAKEOFF checklist. 	
* Note: If Flaps greater than 15, call/select 15. If Flaps are at 15 or less, initially leave flaps at current setting. Retract flaps & gear on schedule.	

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